Project ID: EEMS005

U.S. DEPARTMENT OF ENERGY

SMARTMOBILITY

Systems and Modeling for Accelerated Research in Transportation

Mobility Decision Science

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2017 VTO Annual Merit Review
June 8, 2017

Argonne NATIONAL LABORATORY | INL Idaho National Laboratory | BERKELEY LAB | OAK RIDGE National Laboratory | NREL NATIONAL RENEWABLE ENERGY LABORATORY

SMART Mobility Decision Science (MDS)

Timeline

- Start date: October 2016
- End date: September 2019
- Percent complete: 20%
- **Project is a new start. It was not reviewed in FY16**

Budget

- Total project funding: $9M
  - DOE share: 100%
- FY 2016: Zero
- FY 2017: $3M

Barriers

- Consumer reluctance to purchase new technologies
- Use-phase energy efficiency in transportation can be improved
- Energy impact of new mobility technologies (CAVs, TNCs, etc) uncertain

Partners

- Project Lead: LBNL
- Partners: NREL, ANL, INL, ORNL, RSG, UC Berkeley, UIC, Univ of Maine, University of Iowa, University of NSW

MDS Project Context

Technological Advances

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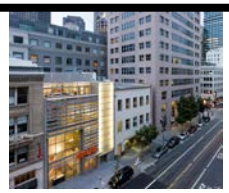


Emergent Mobility Preferences

Mobility-as-a-Service

lyft UBER

Transport Electrification

CAVs

Online Life

MDS Goals, Metrics & Scope

Mega-Trends → Decision-makers ↓	Mobility as a Service	Transportation Electrification	Connectivity and Automation	Online Shopping
Travelers/Consumers	SMART Mobility Decision Science Research Goals 1. Prioritize investment in technology 2. Inform Policy Design 3. Design smart, behaviorally-aware programs Metrics Reduce energy consumption & GHG emissions and improve economic competitiveness			
Firms/Transportation Suppliers				
Institutions (Government, Civil Society Orgs, Planners)				

Project Approach

Descriptive Behavioral Research leads to Normative

Descriptive Research Tasks

1. WholeTraveler Project and Data Analysis
2. Descriptive Transportation Behavior and System Analysis Supplemental to *WholeTraveler*
    1. Value of travel time in the context of new mobility services
    2. TNC service availability and vehicle sales
    3. Factors influencing PEV charging behavior

Normative Research Tasks

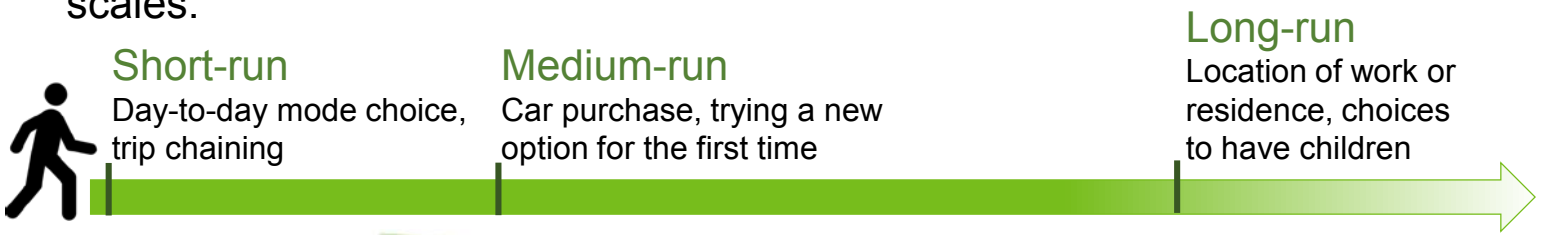
3. Large-scale Agent-Based Mobility Behavior Simulation Modeling for Energy Efficiency

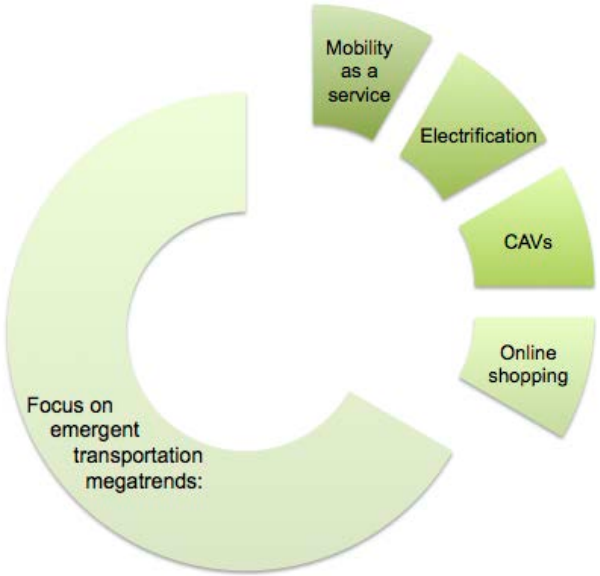
Milestones

Date	Milestones	Status
December 2016	Detailed project plan for Wholetraveler	Completed
March 2017	Data collection and analysis plan for estimating value of non-driving travel time	Completed
June 2017	Enable full range of multi-modal travel decision making in Agent-based transportation system models (BEAM, POLARIS)	On schedule
September 2017	Behavioral scenario simulations to estimate system energy demand for SF Bay Area and Chicago	On schedule
September 2017	Report on empirical assessment of PEV charging behavior	On schedule

WholeTraveler Survey

- Develop and integrate innovative survey methods, GPS data collection mechanisms, and cutting edge analytics.
- Integrated assessment of drivers/barriers of transportation choices across multiple time scales:

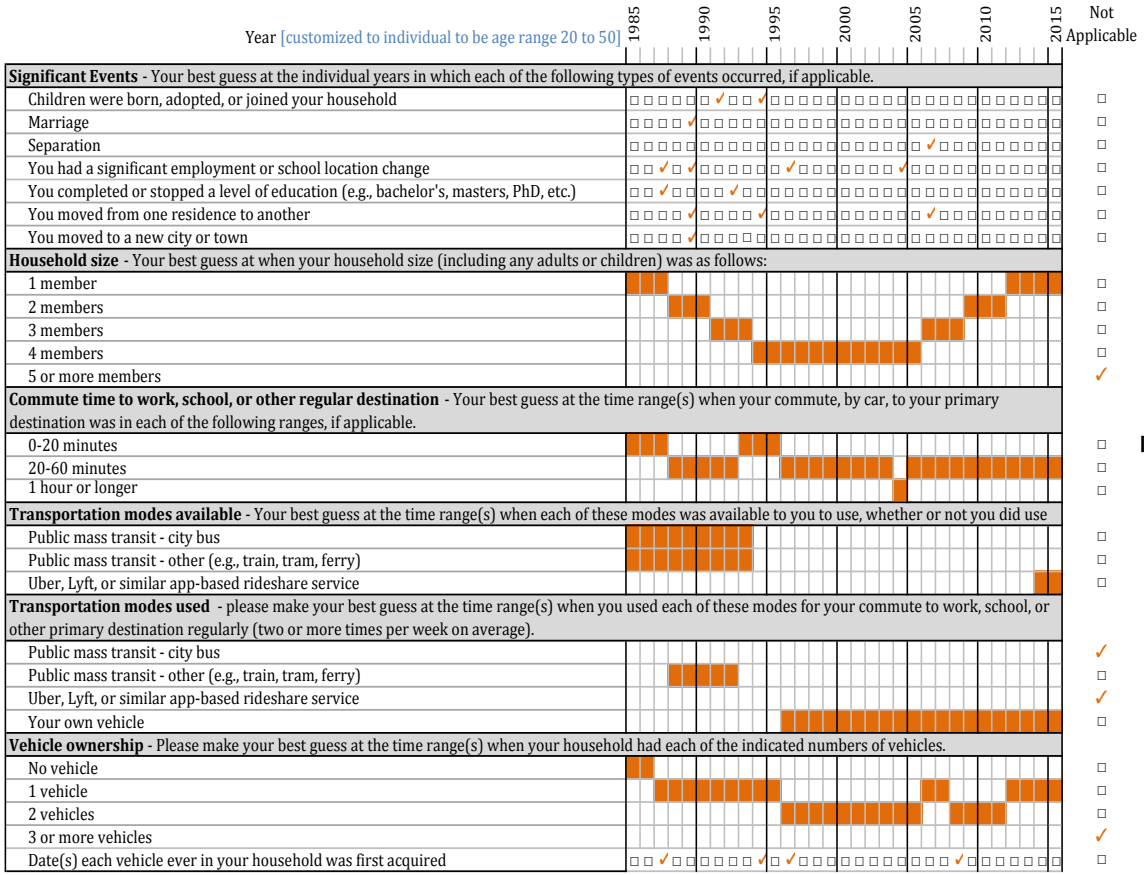




- Focus on impact of:
  - Long-run lifecycle trajectory patterns;
  - Psychological and personality characteristics;
  - Risk and time preferences
- Collect a rich array of information to study heterogeneous effects.

WholeTraveler – Technical Accomplishments

- **Developed and tested Life History Calendar**

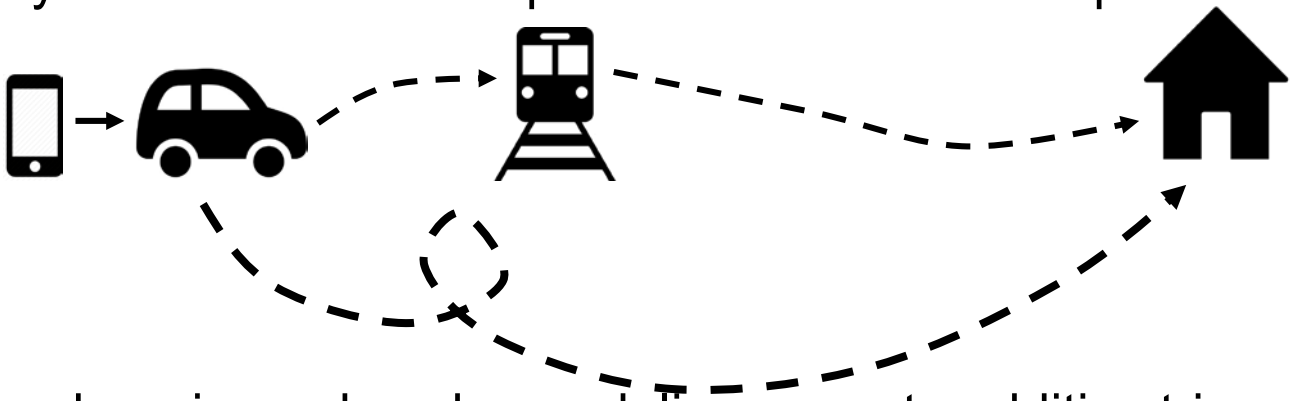


Year [customized to individual to be age range 20 to 50]	1985	1990	1995	2000	2005	2010	2015	Not Applicable
Significant Events - Your best guess at the individual years in which each of the following types of events occurred, if applicable.								
Children were born, adopted, or joined your household		✓	✓					
Marriage			✓					
Separation					✓			
You had a significant employment or school location change	✓	✓		✓	✓			
You completed or stopped a level of education (e.g., bachelor's, masters, PhD, etc.)	✓		✓					
You moved from one residence to another		✓	✓		✓			
You moved to a new city or town		✓						
Household size - Your best guess at when your household size (including any adults or children) was as follows:								
1 member	■	■					■	
2 members		■	■			■		
3 members			■		■			
4 members			■	■	■			
5 or more members								✓
Commute time to work, school, or other regular destination - Your best guess at the time range(s) when your commute, by car, to your primary destination was in each of the following ranges, if applicable.								
0-20 minutes	■	■		■				
20-60 minutes		■	■	■	■	■	■	
1 hour or longer					■			
Transportation modes available - Your best guess at the time range(s) when each of these modes was available to you to use, whether or not you did use								
Public mass transit - city bus	■	■	■					
Public mass transit - other (e.g., train, tram, ferry)	■	■	■					
Uber, Lyft, or similar app-based rideshare service							■	
Transportation modes used - please make your best guess at the time range(s) when you used each of these modes for your commute to work, school, or other primary destination regularly (two or more times per week on average).								
Public mass transit - city bus								✓
Public mass transit - other (e.g., train, tram, ferry)		■	■					
Uber, Lyft, or similar app-based rideshare service								✓
Your own vehicle			■	■	■	■	■	
Vehicle ownership - Please make your best guess at the time range(s) when your household had each of the indicated numbers of vehicles.								
No vehicle	■							
1 vehicle		■	■	■		■	■	
2 vehicles			■	■	■			
3 or more vehicles								✓
Date(s) each vehicle ever in your household was first acquired		✓		✓	✓	✓		

- Unique survey approach only recently applied to transportation behavior research
- Facilitates recall of retrospective information – enables collection of longitudinal data in a single shot survey
- Analysis will identify archetypal lifecycle trajectories associated with various transportation patterns

WholeTraveler – Developed and Tested Innovative Questions to Explore

- Mobility as a Service – compliment or substitute for public transit?

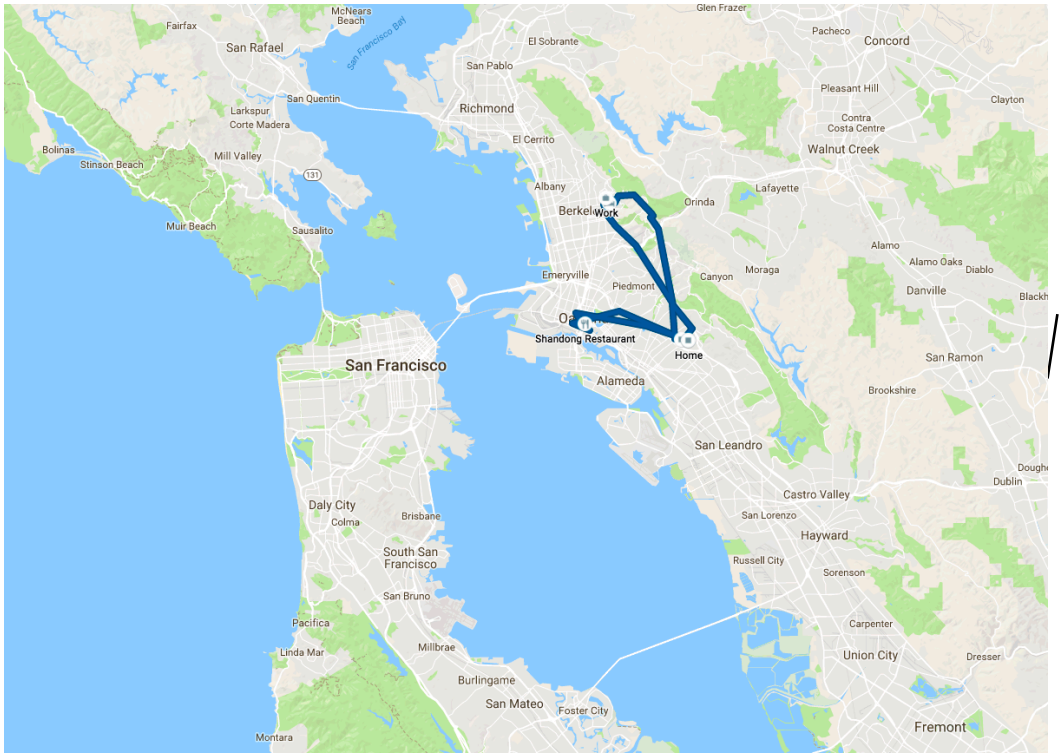


- Online shopping – does home delivery create additive trips or no?

  - Will cross check with GPS data to assess consistency between stated and revealed preferences
  - Responses linked to current vehicle ownership to enable assessment of efficiency implications.

WholeTraveler – Daily Mobility Decisions

- **Revealed preference on mode use and daily mobility decisions**

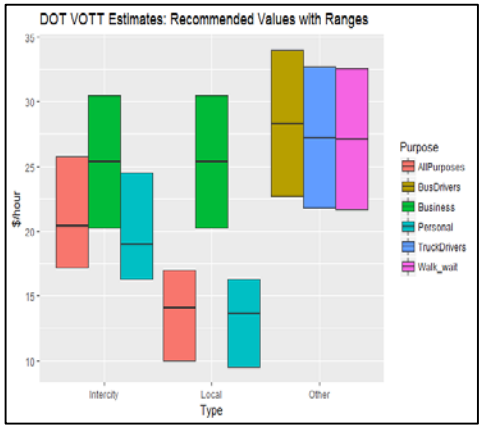


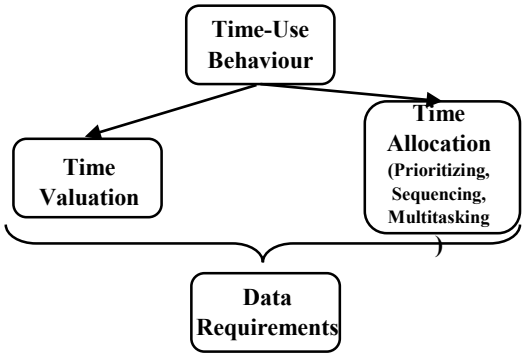
- Developed secure, encrypted method to obtain Google Location History GPS data (opt-in)
- This technical accomplishment will allow participants to quickly and efficiently upload their GPS data to our servers, minimizing user error and improving data collection, without the need for expensive app development
- This daily transportation behavior data will be linked to survey responses in order to develop better predictive models

Travel Time Use and Valuation

- Objective: Evaluate how time-use, activity patterns & travel time-valuations change for differing mobility options.

- Technical Accomplishments to date
  - **Completed conceptual review and data gathering plan**
  - **Initial statistical analysis with existing datasets**





- Exploratory analysis focusing on ATUS and HTS (e.g. CMAP) datasets
- Modeling time allocation patterns and implied valuations
- Working to ID key supplemental data and design approach to gain via survey or social media: e.g. info on multitasking; travel time quality attributes for alt modes

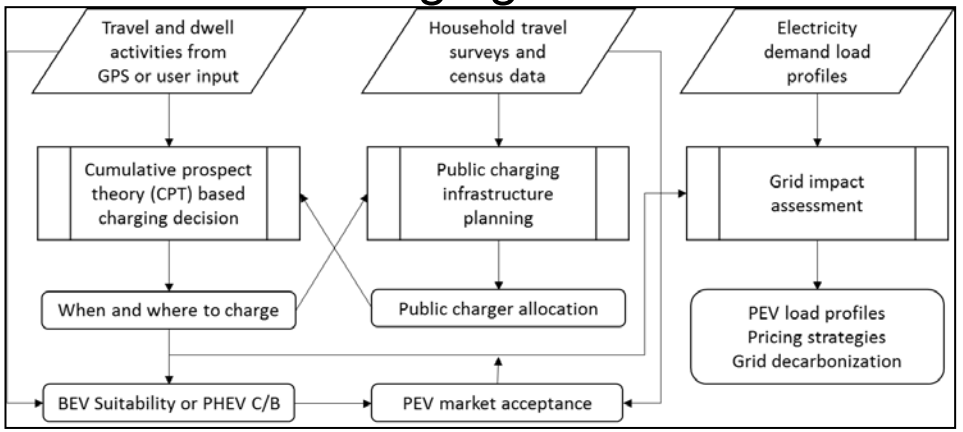
Effect of TNC Supply on Vehicle Sales by Region

- Objective: Estimate the correlation between Transportation Network Company service supply and vehicle sales in a metropolitan region

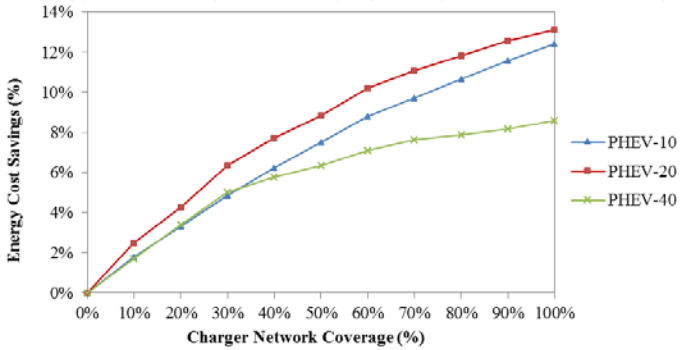
- Approach
  - –Select region(s) with atleast 5 years of widespread TNC supply
  - –Use Polk/IHS registration data to track vehicle sales at high spatial resolution
  - –Procure TNC supply and pricing over time
  - –Construct econometric correlation after controlling for numerous factors: mode share, transit quality of service, etc

Analysis of Charging Behavior

- ✓Developing a bottom-up model of PEV driver's charging behavior and quantify its collective effects
  - ✓Use heterogeneity
  - ✓Day-to-day variations
  - ✓Imperfect information
  - ✓Infrastructure interdependency
- ✓Develop empirically derived charge event generating mechanism
  - ✓Timing of charge events as a function of the state of charge
- ✓Will validate charging behavioral model using different vehicle data (Tesla Model S, BMW i3, etc.)

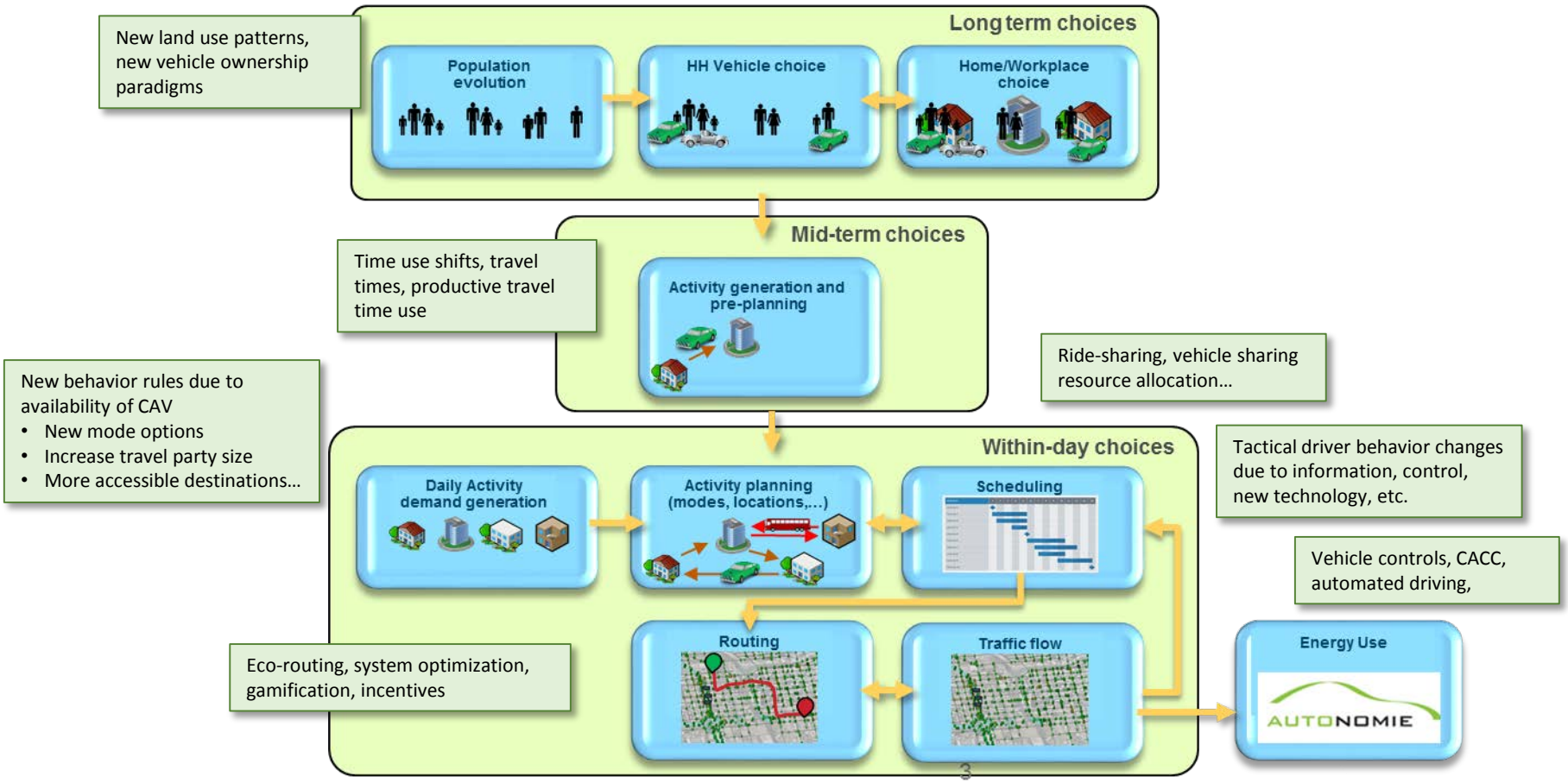


Energy cost savings with varying charger network coverage



Progress

Mobility Behavior & Models



POLARIS Behavior Modeling FY17 Accomplishments

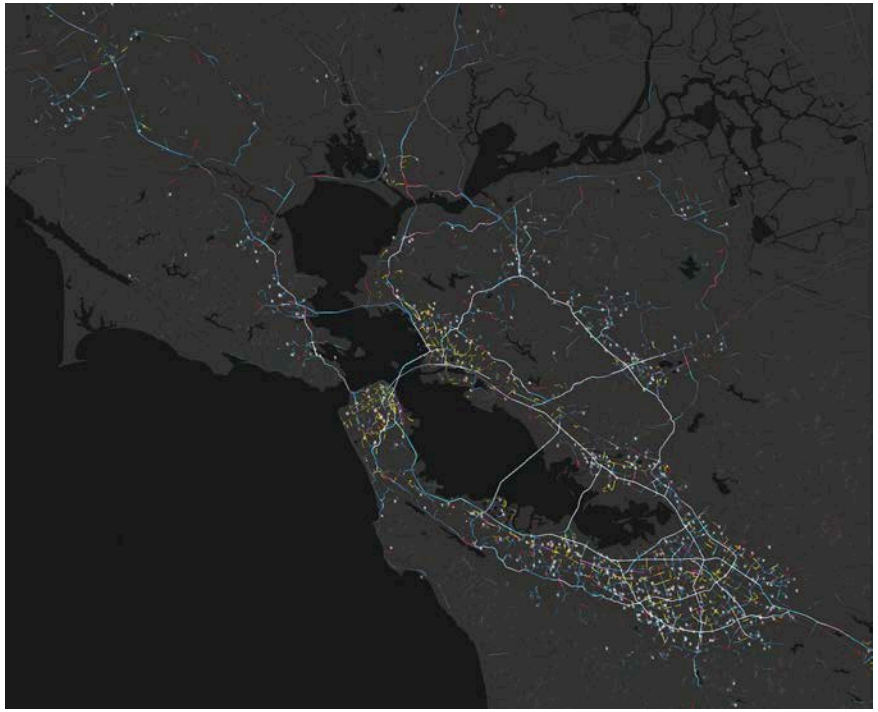
- Polaris improvements over the previous two quarters: utilized in CACC response case study under CAV pillar:
  - New mode choice model framework – nested logit model with auto, transit and non-motorized categories
  - Household vehicle transaction framework – assign vehicle types and technologies to individual households
  - Trip vehicle selection framework – select from household vehicle list for individual usage
- Current POLARIS updates in process and over the remainder of the year:
  - **Activity generation model** (*impact of smart mobility on activity patterns*)
    - Implement hazard-based activity generation equations in Polaris
    - Update with results of time-use and valuation study to modify activity generation
  - **Advanced scheduling and conflict resolution model** (*ridesharing, shared fleet*)
    - Replace current scheduling heuristics in Polaris with optimization model (UIC)
    - Development of household vehicle use scheduling (necessary for ZOV, shared fleets, etc)
  - **Dynamic time-of-day choice model** (*incentive & pricing*)
    - Replace distribution draws with dynamic planning-constrained time choice model (UIC)
    - Ensure sensitivity to transportation level-of-service, modal characteristics, etc.
  - **Household location choice and vehicle transactions** (*long term impacts of smart mobility*)
    - Finish developing framework for interacting with long-term choice models
    - Integration point with land-use (UrbanSim) and vehicle choice (MA3T, household transaction model)

BEAM Behavior Modeling FY17 Accomplishments

- BEAM is a re-designed mobility simulation engine that runs in MATSim
- BEAM Agents (persons, vehicles, infrastructure, artificial controlers) are finite state machines
- BEAM Agents are programmed using the actor model of computation and deployed using the open source Akka framework
- Multimodal Routing: Leveraging existing Open Trip Planner software to simulate customizable trip planning
- Preliminary multinomial logic mode choice model, designed to be extended
- Together, these improvements enable scalable multimodal simulations with rich treatment of traveler behavior
- TNC operations: carpooling and empty vehicle redistribution

Simulation Model Visualizations

BEAM



POLARIS

MDS is a Multi-lab Project

- Mobility Decision Science is part of the SMART Mobility Consortium – a multi-lab consortium project
- LBNL is lead, other participating labs are:
  - ANL, ORNL, INL, NREL
- Additionally, we have university partners:
  - University of California Berkeley, University of Illinois Chicago, University of Maine
- Coordinating with ARPA-E TRANSNET program

Remaining Challenges & Barriers

- WholeTraveler
  - –Successful completion of IRB Human Subjects Review
  - –Successful collection of sample data
- Empirical Behavioral Studies
  - –Data availability for all 3 tasks may restrict the strength of conclusions
- Travel Behavior Simulation Modeling
  - –Calibration & Validation
  - –Extension to other cities
  - –Rapid enabling of high performance computing platforms
  - –Leverage Wholetraveler and empirical studies results

Proposed Future Work

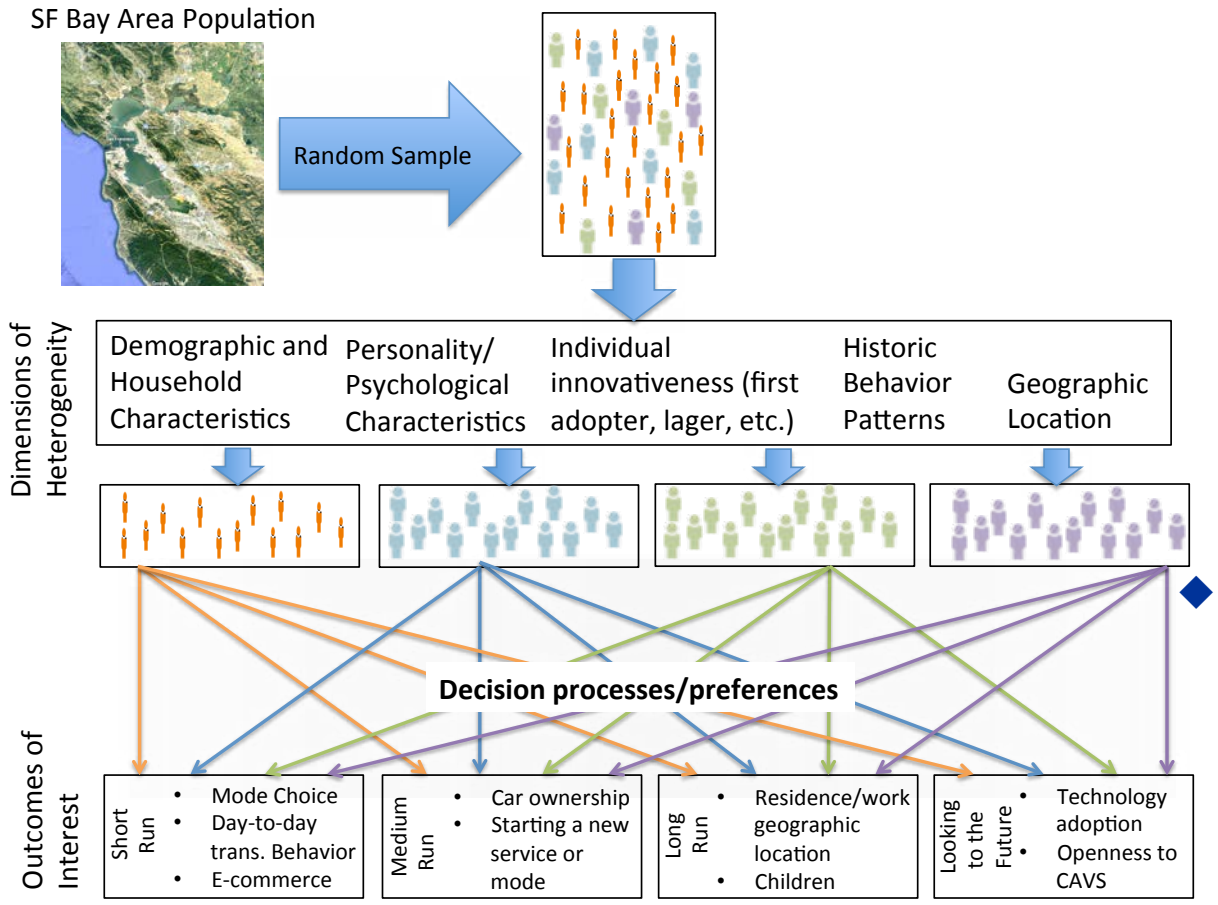
- WholeTraveler Any proposed future work is subject to change based on funding levels
  - In FY17 parallel to IRB review and data collection:
    - Refining and testing analysis plans
    - Writing background and methods sections of papers
    - Primary analysis post-survey
    - Ambitious set of analyses the data have been designed to support and FY18 will see a large amount of that completed.
- Develop other empirical assessment tasks for FY18
- Complete ABM development
- Link ABMs to land use and population changes
- Test policy and behavioral program outcomes

MDS Project Summary

- WholeTraveler Survey will attempt to understand the major correlates of short, medium and long-term mobility behavior
- Empirical behavioral studies will complement WholeTraveler in understanding travel behavior in the face of mobility mega-trends
- Above tasks will send behavioral inputs to large-scale HPC enabled agent-based transportation system simulation models that can test energy outcomes of policies and programs

Technical Backup Slides

WholeTraveler



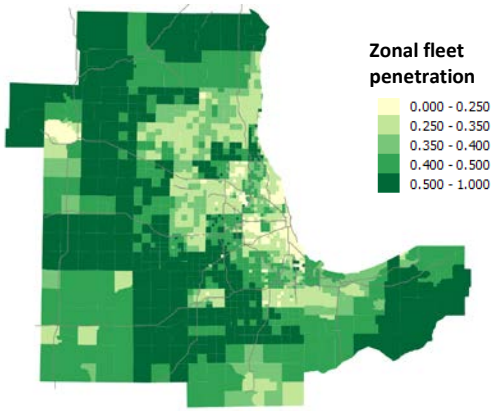
- Phase 1 Online Survey
  - SF Bay Area: Alameda, Marin, Contra Costa, Napa, San Francisco, San Mateo, Santa Clara, Solano Counties
  - Target completed responses: 900
  - Address-based random sample with assumed 3% response rate
  - Incentive payment: $10
- Phase 2 GPS Location Data
  - Open to all Phase 1 participants
  - Using Google Location History data (collected for one week)
  - Incentive payment: $20
  - Target completed responses: 200

Case Study under CAV Pillar leveraging MDS models

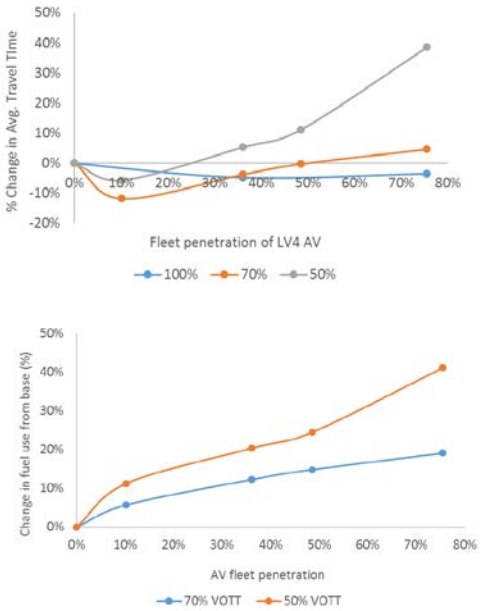
- CAV impacts due to capacity and VOTT changes
  - Case study using POLARIS to model energy impact of privately owned level-4 AV deployment due to demand changes
    - Willingness to pay from Bansal et al 2016, coupled with HH vehicle choice model
    - Range of VOTT impact from 50% to 70% of SOV driver
    - Link capacity increase due to CACC from Shladover et al (2012)

Case study setup			
Run	AV cost	VOTT change	Fleet pen.
0	--	0%	0%
1.1	$15,000	-30%	13.4%
1.2	$5,000	-30%	47.8%
1.3	$2,500	-30%	64.2%
1.4	$0	-30%	100.0%
2.1	$15,000	-50%	13.4%
2.2	$5,000	-50%	47.8%
2.3	$2,500	-50%	64.2%
2.4	$0	-50%	100.0%

Level 4 geographic distribution (cost = $5000)



Case study mobility and energy results



QUESTIONS?